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CORRELATION PROPERTIES OF INTERSTELLAR DUST: DIFFUSE
INTERSTELLAR BANDS

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Results are presented here from a research programme in which we attempt to establish the physical nature of the interstellar grains, and the carriers of the diffuse interstellar bands, by comparing relations between different observed properties; the properties used include the extinction in the optical and ultraviolet (including $\lambda 2200$ and the far-UV rise), cloud density, atomic depletions, and strengths of the diffuse bands. We use our own observations and also data from the literature, selecting particularly sight-lines where some observed property has been found to have anomalous behaviour.

In the case of the diffuse bands, it has been found that the standard catalogue prepared by Snow, York and Welty (1977) contains fundamental compilation errors (Somerville, 1988a). These have been corrected and a revised and updated catalogue compiled. The new dataset for $\lambda 4430$ is in Figure 1. Values from different observers have been scaled onto a common basis, using a consistent procedure; for stars with several observations a mean value has been used in the diagram. The absolute observational error is obtained by comparing different observations for the same star. It is seen that, while the correlation with $E(B-V)$ is good, the scatter in the distribution is distinctly wider than the spread that would correspond to observational error; further, there are roughly equal numbers of points anomalously strong and anomalously weak relative to the centre of the distribution.

These results indicate that the strength of $\lambda 4430$ is much more closely related to $E(B-V)$ than it is to the distribution of any known molecule. The similar numbers of sight-lines with strong and weak absorption means that

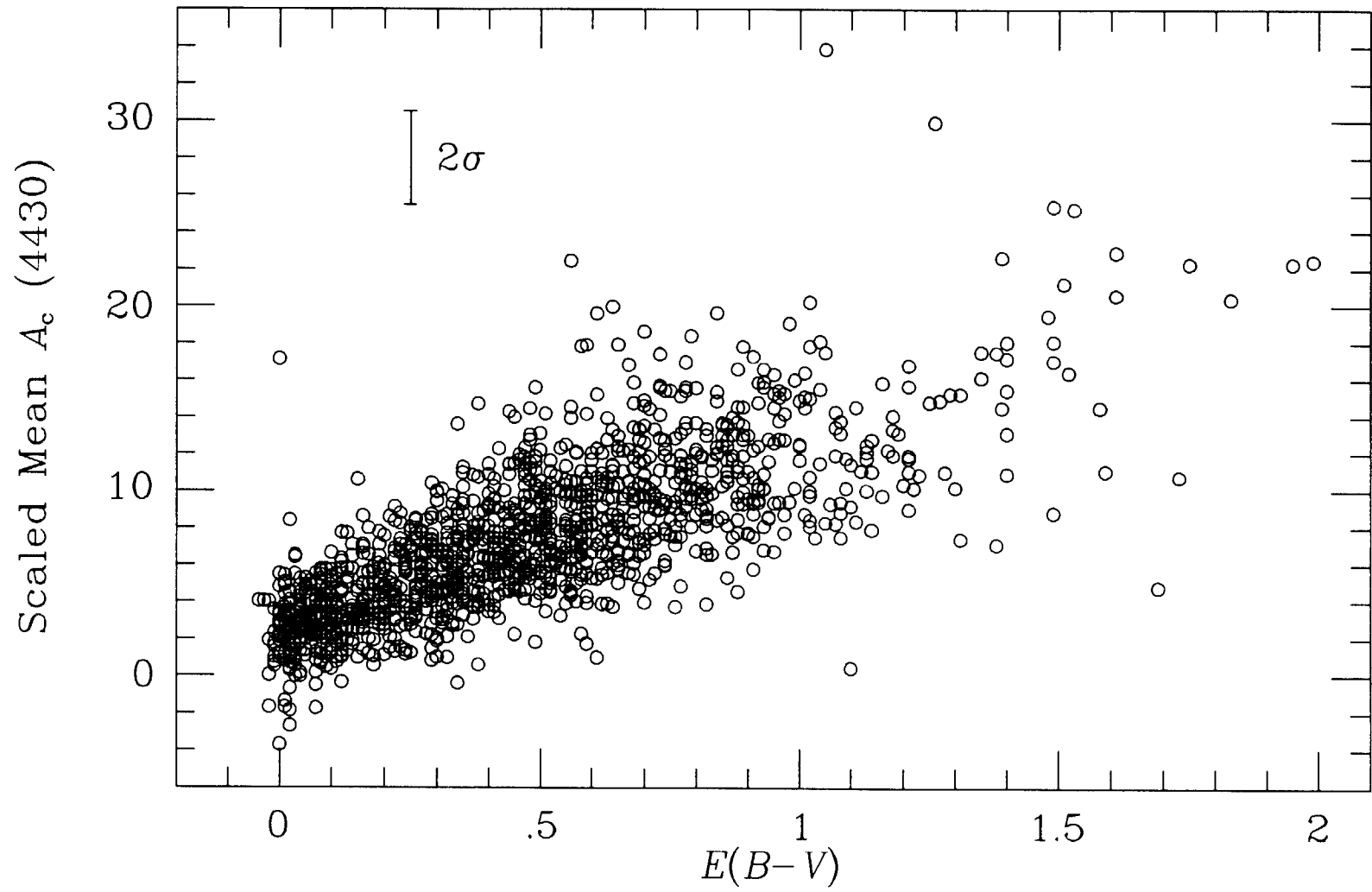


Figure 1. The new $\lambda 4430$ dataset

the strength is not simply a function of interstellar cloud density - if, for example, the absorption were always weak in regions of low density it cannot be that it is always strong in regions of high density for these are much more widespread. It seems rather that anomalously weak and anomalously strong absorption both occur in particular local regions.

The diffuse bands $\lambda 4430$ and $\lambda 5780$ have been examined in relation to atomic depletions and cloud density. It is found that, contrary to previous claims, the strengths of the diffuse bands are independent of these quantities (Somerville, 1988b). Previous analyses (Millar and Duley, 1979; Federman et al., 1984) are in error through the neglect of non-zero intercepts in correlations with $E(B-V)$. It is seen in Figure 2 that the measure P of $\lambda 4430$ strength per grain used by Millar and Duley is systematically high for low $E(B-V)$, compared with other measures, giving the false appearance of a dependence. This is in consequence of dividing the $\lambda 4430$ strength - which, as seen in Figure 1, is non-zero at $E(B-V)=0$ - by a quantity which goes to zero with $E(B-V)$, in this case the total hydrogen column density. The non-zero value at $E(B-V)=0$ is non-physical; it comes through including weak stellar lines in the profile when it is observed at low spectral resolution (Blades and Somerville, 1977, 1981). Similar considerations show that the systematic trend found by Federman et al. (1984) for $\lambda 5780$ is unlikely to be real.

This result that the strength of a diffuse band absorption per grain is unrelated to the interstellar cloud density is consistent with what is found from the $\lambda 4430$ catalogue (Figure 1); it provides strong evidence that these absorptions are not produced either by gas-phase molecules or by surface processes on grains.

In an extended observational programme, we have surveyed nine diffuse bands in the yellow-red region, in 123 stars, from the Lick Observatory (McNally et al., 1987 and in preparation). Detailed error analysis by Rees (1988) leads to the conclusion that for two features, $\lambda 5780$ and $\lambda 6283$, there is a real physical scatter relative to $E(B-V)$. For the seven other features, there is no unambiguous evidence for any scatter beyond what can be attributed to observational error.

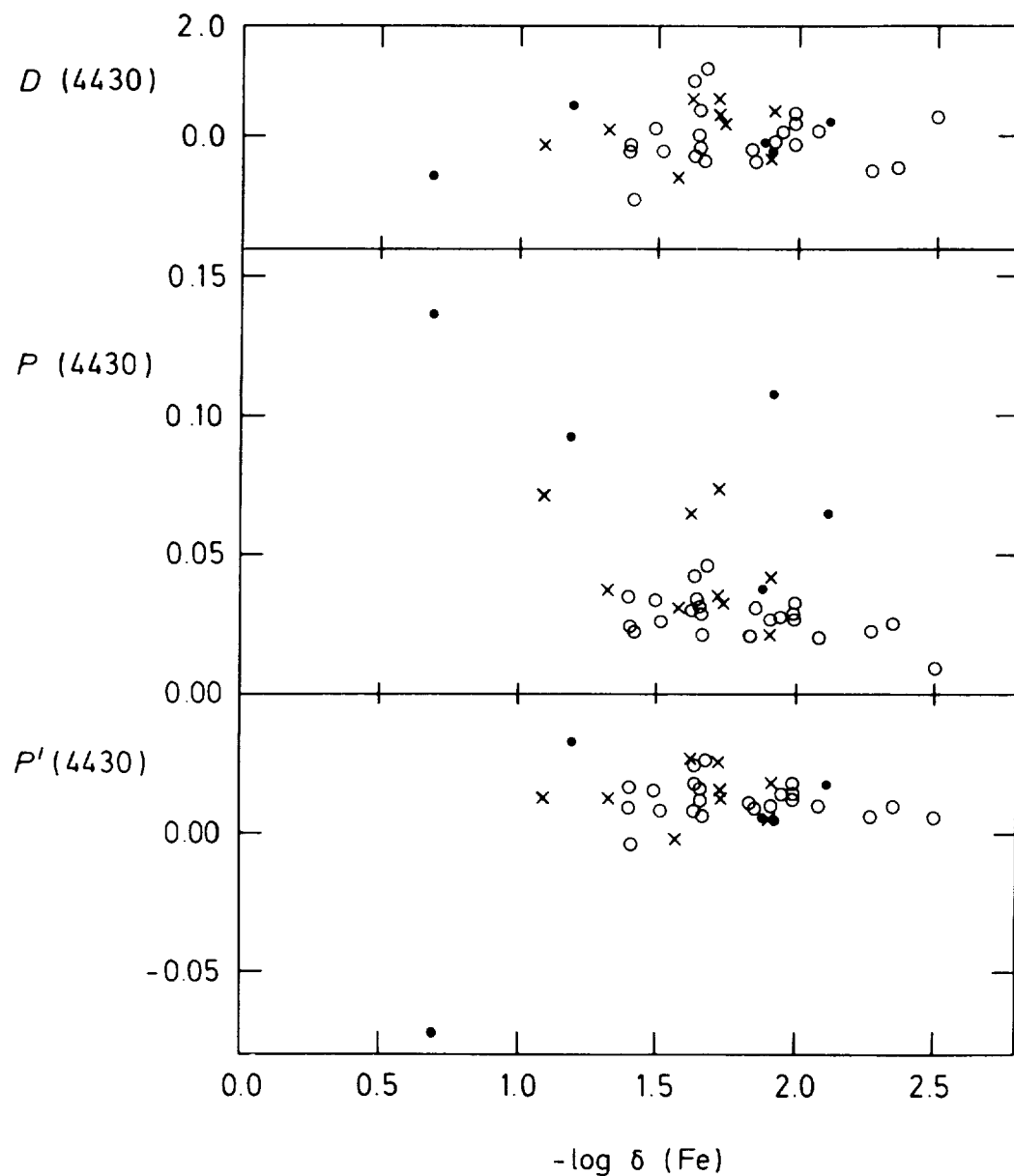


Figure 2. The relation of three measures of '4430 strength per dust grain' to iron depletion. Solid points: $E(B-V) < 0.1$, crosses: $0.1 < E(B-V) < 0.2$, open circles: $0.2 < E(B-V)$. The quantity $P(4430)$, used by Millar and Duley (1979), shows a false dependence not seen for the two other quantities (Somerville, 1988b).

Taking all these results together, they indicate that the carriers of the bands must be very closely related to the grains that produce optical extinction, and absorb by some mechanism independent of the cloud density. This favours a mechanism involving internal processes in grains, or some bulk property of the grains, that operates independently of the gaseous environment.

References

Blades, J.C. and Somerville, W.B.: 1977, Mon. Not. R. Astr. Soc. 181, 769.

Blades, J.C. and Somerville, W.B.: 1981, Mon. Not. R. Astr. Soc. 197, 543.

Federman, S.R., Kumar, C.K. and Vanden Bout, P.A.: 1984, Astrophys. J. 282, 485.

McNally, D., Ashfield, M., Baines, D.W.T., Fossey, S., Rees, P.C.T., Somerville, W.B. and Whittet, D.C.B.: 1987, IAU Symposium 120: Astrochemistry, ed. M.S. Vardya and S.P. Tarafdar (Dordrecht: Reidel), 321.

Millar, T.J. and Duley, W.W.: 1979, Mon. Not. R. Astr. Soc. 187, 379.

Rees, P.C.T.: 1988, Ph.D. thesis, University of London.

Snow, T.P., York, D.G. and Welty, D.E.: 1977, Astr. J. 82, 113.

Somerville, W.B.: 1988a, Astr. J., submitted.

Somerville, W.B.: 1988b, Mon. Not. R. Astr. Soc., in press.

